Table 8-5.-Viscosity Grades at Room Temperature

VISCOSITY COMPARISONS

COMMON MATERIALS	WATER	LIGHT SYRUP	SYRUP	MOLASSES	HEAVY MOLASSES	BARELY DEFORM	SOLID

RT GRADES	1	2	3	4	5	6	7	8	9	10	11	12

RTCB	5	6

ASPHALT CEMENT

200	150	100	60	40
300	200	150	100	60

ASPHALT CUTBACKS

30	70	250	800	3000

KINEMATIC VISCOSITY AT 140° CENTISTOKES

NEW GRADES: MC-30, SC-70, RC, MC & SC-250, RC, MC & SC-800, RC, MC & SC-3000

viscosity grades of asphalt cutbacks and asphalt cements by means of table 8-5.

Use of Tars

Tars are suitable for use on areas where asphalt is unsuitable. A good example is an airfield where petroleum distillates are likely to be spilled. Tars do not strip easily from aggregate in the presence of water and is preferred as a prime coat. Tars penetrate more deeply into the base course than will asphalt of the same viscosity and curing rate.

Cold-tar mixes are used for road mix and patching. Hot-tar mixes are used for plant mix, surface treatment, crack fillers, and similar uses. Since tars become soft at high temperatures and brittle at low temperatures, the heavier grades are preferred for use in warm weather and the lighter grades in cool weather.

Road tar cutbacks are used for patching mixes; however, an open flame must NOT be used near storage tanks and drums of road tar cutbacks because they are flammable.

FIELD IDENTIFICATION OF BITUMINOUS MATERIALS

Identifying bituminous materials can be a problem. Stockpiled bituminous materials that are unmarked or improperly marked can cause unnecessary delays in construction operations. Fairly accurate identification is necessary to decide on the type of construction that the materials can be used for, the method of construction to be used, the type and quantity of equipment needed, and the applicable safety regulations to be observed. Some of the tests used in the field to identify bituminous materials as asphalt cement, asphalt cutback, asphalt emulsion, road tar, or road tar cutback are as follows:

- Solubility
- Pour
- Smear
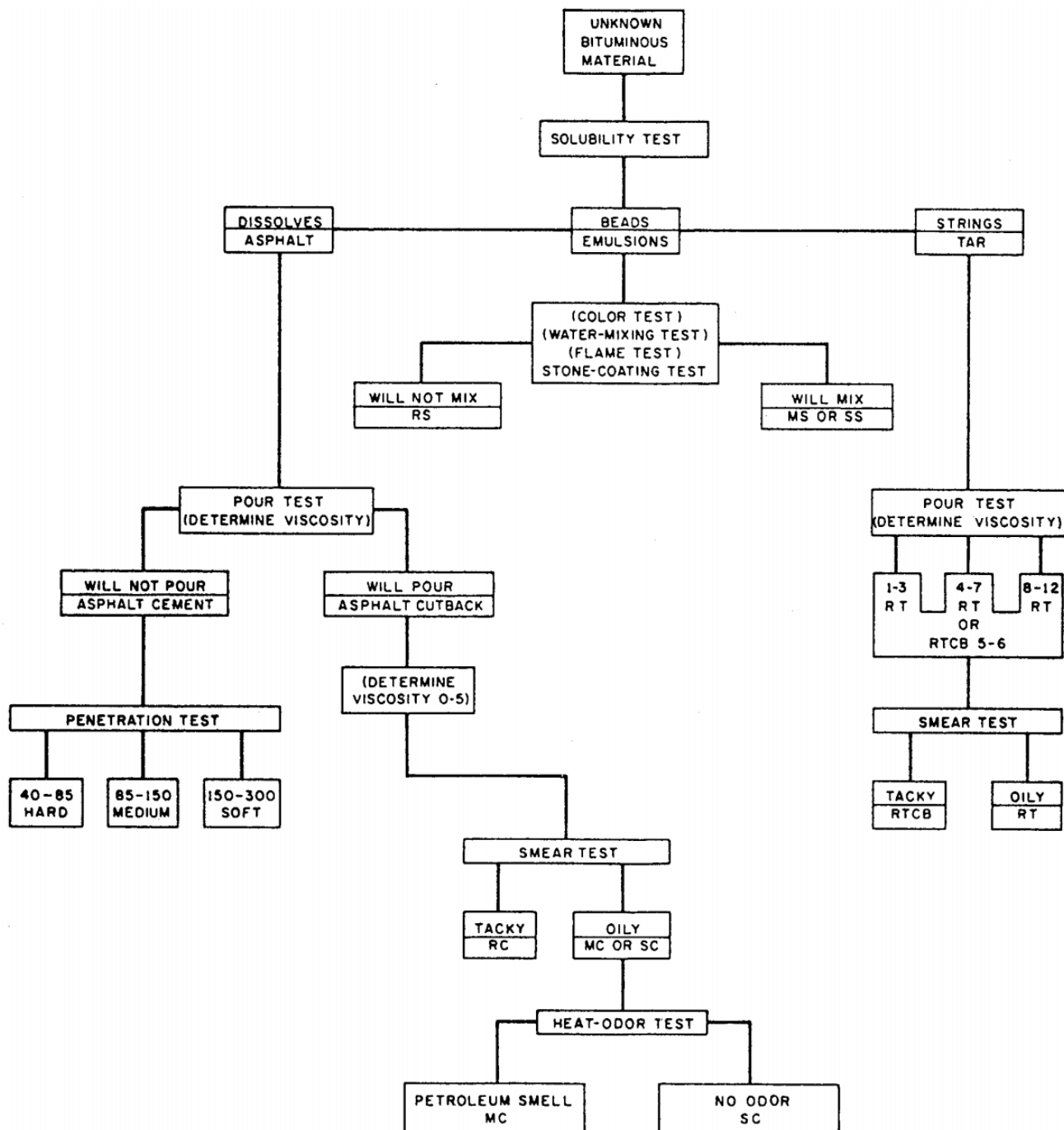- Heat-Odor
- Penetration
- Stone coating

```
                    ┌─────────────────┐
                    │    UNKNOWN      │
                    │   BITUMINOUS    │
                    │    MATERIAL     │
                    └─────────────────┘
                             │
                    ┌─────────────────┐
                    │ SOLUBILITY TEST │
                    └─────────────────┘
                             │
      ┌──────────────────────┼──────────────────────┐
 ┌──────────┐          ┌──────────┐           ┌──────────┐
 │ DISSOLVES│          │  BEADS   │           │ STRINGS  │
 │ ASPHALT  │          │ EMULSIONS│           │   TAR    │
 └──────────┘          └──────────┘           └──────────┘
```

```
                    ┌──────────────────────┐
                    │    (COLOR TEST)      │
                    │ (WATER-MIXING TEST)  │
                    │    (FLAME TEST)      │
                    │  STONE-COATING TEST  │
                    └──────────────────────┘
              ┌────────────┴────────────┐
        ┌──────────────┐          ┌──────────────┐
        │ WILL NOT MIX │          │  WILL MIX    │
        │     RS       │          │  MS OR SS    │
        └──────────────┘          └──────────────┘
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   ┌──────────────────────┐              ┌──────────────────────┐
   │     POUR TEST        │              │     POUR TEST        │
   │(DETERMINE VISCOSITY) │              │(DETERMINE VISCOSITY) │
   └──────────────────────┘              └──────────────────────┘
   ┌──────────┴──────────┐           ┌──────┬───────┬──────┐
┌─────────────────┐ ┌─────────────────┐ │ 1-3 │  4-7  │ 8-12 │
│  WILL NOT POUR  │ │   WILL POUR     │ │ RT  │  RT   │  RT  │
│ ASPHALT CEMENT  │ │ ASPHALT CUTBACK │ │     │  OR   │      │
└─────────────────┘ └─────────────────┘ │     │RTCB 5-6│     │
                                         └──────────────────┘
                    ┌─────────────────┐    ┌─────────────┐
                    │  (DETERMINE     │    │ SMEAR TEST  │
                    │ VISCOSITY O-5)  │    └─────────────┘
                    └─────────────────┘    ┌──────┴──────┐
┌───────────────────────────────┐     ┌────────┐  ┌────────┐
│ PENETRATION TEST              │     │ TACKY  │  │  OILY  │
└───────────────────────────────┘     │ RTCB   │  │   RT   │
 ┌────────┬────────┬────────┐          └────────┘  └────────┘
┌────────┐┌────────┐┌────────┐
│ 40-85  ││ 85-150 ││150-300 │
│ HARD   ││ MEDIUM ││ SOFT   │
└────────┘└────────┘└────────┘
```

```
                    ┌─────────────┐
                    │ SMEAR TEST  │
                    └─────────────┘
              ┌───────────┴───────────┐
         ┌────────┐              ┌──────────┐
         │ TACKY  │              │   OILY   │
         │   RC   │              │ MC OR SC │
         └────────┘              └──────────┘
                         ┌─────────────────┐
                         │  HEAT-ODOR TEST │
                         └─────────────────┘
                   ┌───────────┴───────────┐
          ┌─────────────────┐      ┌──────────────┐
          │ PETROLEUM SMELL │      │   NO ODOR    │
          │       MC        │      │     SC       │
          └─────────────────┘      └──────────────┘
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Figure 8-21.—Field identification of unknown bituminous materials.

Field identification of bituminous materials is summarized in figure 8-21.

Solubility Test

The solubility test consists of taking a small amount of the unknown bituminous material, enough to cover the head of a nail if a solid, or few drops of a liquid material and attempting to dissolve the material by stirring it in a petroleum distillate; gasoline, kerosene, diesel fuel, and so forth. If the material is an asphalt, it will mix uniformly with the distillate. Tars, however, will form a stringy undissolved mass. Emulsions, in addition to other distinguishing tests, may also be identified in the solubility test since they will form undissolved balls or beads of the emulsion at the bottom of the container of petroleum distillate. The solubility test provides a positive method of identification (fig. 8-22).
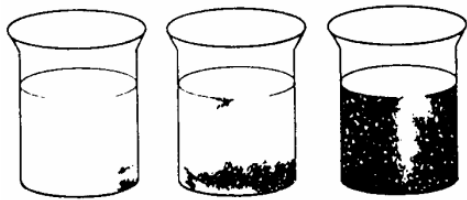
FROM LEFT TO RIGHT: KEROSENE, KEROSENE PLUS TAR, KEROSENE PLUS ASPHALT CEMENT OR ASPHALT CUTBACK.
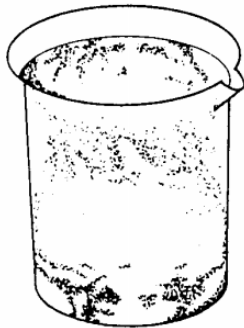
BEADS FORMED BY ASPHALT EMULSION IN KEROSENE.

**Figure 8-22.—Solubility test for asphalt, tar, and emulsion.**

Pour Test

When you perform the volubility test and the bituminous material dissolves, an asphalt product–asphalt cement or asphalt cutback–is present. At room temperature (77 F) asphalt cements are solids, and asphalt cutbacks are fluids. With these facts in mind, you may run a second test, a pour test, to determine whether a sample is an asphalt cement or an asphalt cutback.

In the pour test, an attempt is made to pour the material from a small container. Asphalt cements are solids and will not pour. Asphalt cutbacks are fluids at 77 F and will pour (fig. 8-23).

A pour test is also used to identify the 12 viscosity grades of tar. Viscosity grades of road tar are comparable to the viscosity grades of asphalt cutbacks and asphalt cement (table 8-5). RT-1, the most fluid, is similar in viscosity to the grade 30 of the rapid-curing, medium-curing, and slow-curing types of asphalt cutbacks. RT-8 is similar to grade 800 asphalt cutback. RT-12 has the approximate consistency of asphalt cement of 200-300 penetration.

Road tar grades 4, 5, and 7, which are identical in appearance to road tar cutback grades 5 and 6 may be distinguished through a smear test. Like asphalt
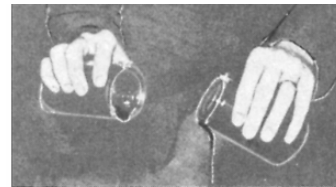
ASPHALT CEMENT ON LEFT. ASPHALT CUTBACK ON RIGHT.
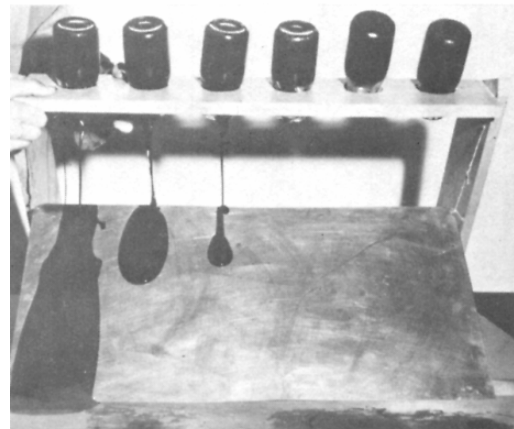
LEFT TO RIGHT: ASPHALT CUTBACKS GRADE 30, 70, 250, 800, AND 3,000 THREE SECONDS AFTER TIPPING FULL JARS.
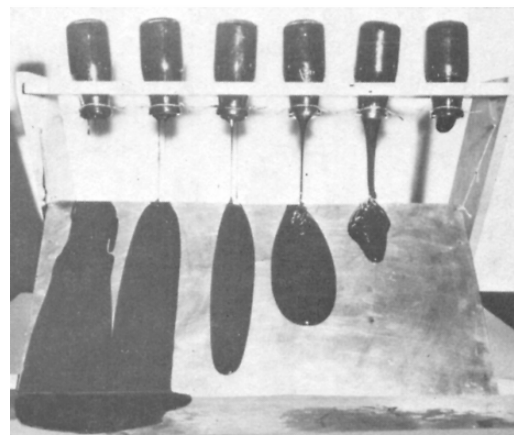
THIRTEEN SECONDS AFTER TIPPING FULL JARS.

143.179

Figure 8-23.—Pour test for asphalt and cutbacks.

cutbacks, road tar cutbacks cure rapidly since they are thinned with highly volatile materials that evaporate quickly and leave a sticky substance within a 10-minute period. On the other hand, because the fluid coal oil in road tars evaporates slowly, road tars will remain at the same consistency at the end of an identical period.
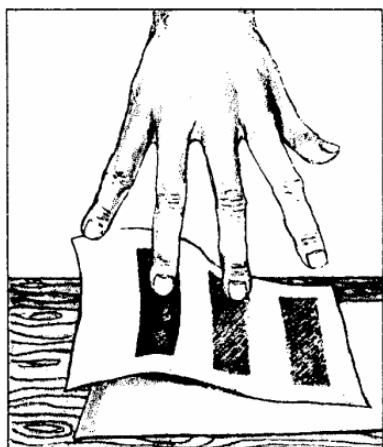
Figure 8-24.–Smear test of asphalt cutback.

Smear Test

The smear test is used to separate an RC from an MC or SC. The test is primarily based on the fact that RCs are cutback with a highly volatile material (naphtha or gasoline). You can determine whether a sample is an RC or not by smearing some of the sample in a thin layer on a nonabsorbent surface, such as a piece of glazed paper. The volatile substance evaporates within a few minutes and the surface becomes so tacky that when touched, the specimen, paper and all, sticks to your fingers and can be lifted into the air (fig. 8-24).

Checking the reverse side of the paper, you will find that the RC did not penetrate through the paper as MCs or SCs do. MCs and SCs on smear tests remain fluid and oily for time periods that vary from hours to days, depending on the type and grade of material. If an 800 or 3,000 grade MC or SC is present, they may become sticky in a few minutes since there is such a small amount of cutterstock in them. When such a viscous grade is present, it is well to confirm the identification of the sample by a *prolonged smear test.* Generally, the MCs and SCs will penetrate through the paper while the RCs will not. You can determine this by observing the back side of the paper.

In a prolonged smear test, a thin smear is made on nonabsorbent paper and allowed to cure completely. If the viscous cutback is all RC-3000, it will cure completely in about 3 hours. When the spot has cured completely (the cutterstock has almost all evaporated), the smear will be almost pure asphalt cement (AC) and will be hard and no longer sticky. If the viscous sample were an MC or SC-800 or 3,000, the spot would still be
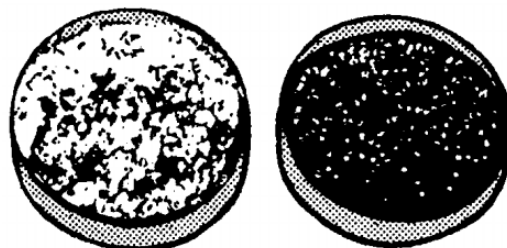
LEFT: DAMP SAND PLUS RS
RIGHT: DAMP SAND PLUS MS OR SS

Figure 8-25.—Stone-coating test for emulsions.

uncured and, therefore, very sticky, even after 24 hours, while the RC smear will have become a hard, glazed spot.

Heat-Odor Test

A heat-odor test is used to distinguish between medium-curing and slow-curing asphalt cutback by identifying the cutter stock as kerosene, fuel oil, or diesel oil. A sample of the material is heated in a closed container to retain the vapors. (CARE MUST BE TAKEN TO AVOID THE USE OF TOO MUCH HEAT). Medium-curing asphalt cutback will have a strong odor of kerosene. Slow-curing asphalt cutback will lack the kerosene odor, but a faint odor of motor oil may be present.

Field Penetration Test

The field penetration test is performed to determine the approximate hardness of the asphalt, not to pinpoint the exact penetration number for it. To determine if the number falls in the hard, medium, or soft group is sufficient.

To perform this test, attempt to push a sharpened pencil or nail into the container of asphalt (at about 77°F), using a firm strong pressure of approximately 10 pounds. If only a slight penetration is made with considerable difficulty, a hard asphalt cement is present. When the penetration is made slowly but without great difficulty, a medium asphalt cement is present. If the penetration is made with ease, the asphalt cement is a high penetration scale (a soft AC).

Stone-Coating Test

When a material has been tested and found to be an emulsion, the stone-coating test is performed (fig. 8-25). This test is conducted to determine if the emulsion is a

LEFT: WATER PLUS TAR OR ASPHALT CUTBACK

RIGHT: WATER PLUS ASPHALT EMULSION

Figure 8-26.-Water-mixing test for emulsions.

rapid setting emulsion termed *a nonmixing* grade or a medium- or slow-setting emulsion termed as mixing grade emulsion. To know which type is present is important because the applications of the mixing and nonmixing types vary greatly. The test performed to distinguish between these two types of emulsions is the stone-coating test. This test consists of taking a handful of damp sand and adding to the sand a small amount of emulsion (estimate about 6 to 8 percent by weight) and attempting to mix the two materials. Care should be exercised not to add so much emulsion that the sand becomes saturated.

A rapid-setting emulsion will "break" so quickly it will not be possible to mix it with sand. It breaks immediately, gumming up the mixing spoon and the aggregate with asphalt cement; otherwise, if the unknown sample is a medium- or slow-setting emulsion when added to the damp sand, it will mix easily and coat all the particles completely as well as the mixing spoon with a uniform coating of asphalt. Identification of an emulsion merely as a mixing or nonmixing type is sufficient for field conditions. The difference in viscosity is unimportant because there are so few grades. No distinction is necessary between medium- and slow-setting emulsions since both are mixing types used largely for the same purpose.

Another test for emulsions is the *WATER-MIXING TEST* (fig. 8-26). Because emulsions are made with water, more water may be added to emulsions without disturbing the uniformity of the liquid. None of the other bituminous materials will dissolve in water.

A *FLAME TEST* can also be used in testing asphalt emulsions. A cloth saturated with asphalt emulsion will smolder but will not burn or burst into flame. Other bituminous materials are combustible.

Laboratory Test of Bituminous Materials

In addition to the field tests, various tests are performed on bituminous materials in the laboratory. These tests usually are made for the purpose of checking compliance with the established specifications; however, laboratory tests may also be made to identify the material beyond field identification, to furnish information for mix design, or to establish safe handling procedures.

Bituminous materials are produced to meet the specification established by the federal government, the American Association of State Highway Officials (AASHO), and the American Society for Testing Materials (ASTM). These specifications define the extreme limits permitted in the manufacture of the material and assure the user that the material will possess definite characteristics and fulfill the project requirements. Consult with the EAs for the proper specifications required.

ESTIMATION OF MATERIALS

Many different combinations of materials are used on bituminous surfaces. Before a bituminous surface is placed, the surface to be covered normally requires the placing of a preliminary treatment: a prime or a tack coat.

Prime Coat

Prime coats are placed on a dirt or gravel surface. The purpose of priming is to waterproof and dustproof the surface, plug capillary voids, and coat and bond loose particles. A prime coat also hardens or toughens the surface, promotes adhesion between the existing surface and the new surface, and penetrates the surface. The priming material may be one of the following:

- A low-viscosity tar, such as RT-2, RT-3, or RT-4
- A low-viscosity asphalt, such as MC-30, -70, -250, or SC-70, -250, -800
- A diluted asphalt emulsion

Bituminous materials used for the prime coat should be applied in quantities known as the rate of application (ROA) of not less than 0.2 gallon or more than 0.5 gallon per square yard. Normally, the construction project specifications denote the ROA for the prime coat application; however, when the ROA is not included in the project specifications, the NCF uses an ROA of .3 for planning purposes.

To estimate the amount of bitumen required for the prime coat, multiply the area to be treated by the rate of application. Under certain conditions, the estimate should include sufficient bitumen for an additional width of 1 foot on each side of the surface course to be constructed on the primed base.

The formulas for a prime coat estimate are as follows:

For computing gallons:

Step 1:

Gallons of Prime Coat Required

$$= \frac{ROA \times L \times (W + 2)}{9}$$

Step 2:

Gallons Needed for *Waste*

$$= Gallons\ of\ Prime\ Coat \times WF\ (.05\ or\ .10)$$

Step 3:

Total Gallons Required

$$= Gallons\ of\ Prime\ Coat + Waste\ Gallons$$

For computing drums:

Step 1:

Drums of Prime Coat Required

$$= \frac{ROA \times L \times (W + 2)}{9 \times 53}$$

Step 2:

Drums Needed for *Waste*

$$= Drums\ of\ Prime\ Coat \times WF\ (.05\ or\ .10)$$

Step 3:

Total Drums Required

$$= Drums\ of\ Prime\ Coat + Waste\ Drums$$

Where:

G = gallons of bitumen primer

D = drums of bitumen primer

L = length of treated section in feet (5,280 feet equal one mile)

W = width of treated surface in feet

ROA = rate of application of bitumen in gallons per square yard

WF = waste factor of bitumen = 5% at .05 or 10% at .10. The value of the factor depends on the experience of the asphalt distributor truck crew

9 = square feet per yard conversion factor

53 = gallons per drum

Example: The specifications and other data for a prime coat project are as follows:

L = 3 miles = 3 × 5,280 feet = 15,840 feet

W = 24 feet

ROA = 0.3 gal/sq yd

WF = 5 percent (or) .05

Find the number of gallons of bitumen (G) necessary to do this project.

Solution:

Gallons required for the project without waste considered:

$$Gallons = \frac{.3 \times 15,840 \times (24 + 2)}{9} = \frac{123,552}{9}$$

$$= 13,728\ gallons$$

Compute waste factor:

13,728 *Gallons* × *WF of* .05 = 686.4 *Gallons*

Total gallons required for the project:

686.4 *Gallons* + 13,728 *Gallons* = 14,414.4 *Gallons*

Always round your answer to the next higher number. In this case, 14,414.4 is rounded to 14,415 gallons.

Tack Coat

A tack coat is a coating of asphalt on an existing paved surface that provides a bond between the existing surface and the new surface, The two essential properties of a tack coat are as follows: (1) it must be very thin and (2) it must uniformly cover the entire surface of the area When tack

coats are too heavy, they leave a surplus of asphalt that bleeds into the overlying course. A thin tack coat does no harm to the pavement and properly bonds the courses.

Tack coat materials may be as follows: (1) a road tar, grade RTCB 5-6, RT-6, 7, 8, 9, 10, or 11; (2) an asphalt cutback, such as RC-250 or -803; (3) a diluted emulsion; or (4) an asphalt cement, such as an AP-3 (85-100 penetration) or AP-1 (120-150 penetration).

Bituminous materials for the tack coat should be applied in quantities not less than 0.05 or more than 0.25 gallon per square yard. The exact quantity depends upon the condition of the surface to be tacked. Normally, the construction project specification denotes the ROA for the tack coat application; however, when the ROA is not included in the project specifications, the NCF uses an ROA of .15 for planning and estimating purposes.

The procedure for estimating the bitumen required for a tack coat is similar to that described for a prime coat except that the tack coat is applied only over the proposed width of the pavement.

The formulas for a tack coat estimates are as follows:

For computing gallons:

Step 1:

$$Gallons\ of\ Tack\ Coat\ Needed = \frac{ROA \times L \times W}{9}$$

Step 2:

Gallons Needed for *Waste*

= *Gallons of Tack Coat* × *WF* (.05 *or* .10)

Step 3:

Total Gallons Required

= *Gallons of Tack Coat* + *Waste Gallons*

For drums, the formulas are as follows:

$$Drums\ of\ Tack\ Coat = \frac{ROA \times L \times W}{9 \times 53}$$

Drums Needed for *Waste*

= *Gallons of Tack Coat* × *WF* (.05 *or* .10)

Total Drums Required

= *Drums of Tack Coat* + *Waste Drums*

G = gallons of bitumen primer

D = drums of bitumen primer

L = length of treated section in feet

W = width of treated surface in feet

ROA = rate of application of bitumen in gallons per square yard

WF = Waste factor of bitumen = 5% at .05 or 10% at .10. This will depend on the experience of the distributor truck crew

9 = square feet per yard conversion factor

53 = gallons per drum

Example: The specifications and other data for a tack coat project are as follows:

L = 2.7 miles = 2.7 × 5,280 = 14,256 feet

W = 24 feet

ROA = 0.05 gal/sq yd

WF = 5 percent or .05

Calculate the number of drums of bitumen needed to accomplish this project.

Solution:

Step 1:

$$Drums = \frac{.05 \times 14,256 \times 24}{9 \times 53}$$

$$= \frac{17,107.2}{477} = 35.86\ Drums$$

Step 2:

Waste = 35.86 *Drums* × *WF of* .05 = 1.79 *Drums*

Step 3:

Total Drums Needed = 1.79 + 35.86 × 37.65 *Drums*

This project requires 38 drums of bitumen.

Surface Treatment

Bituminous materials and aggregate are combined in various proportions to obtain the most satisfactory surface for a given situation. Accurate estimates are required to avoid production delays because of inadequate supplies. You also want to avoid oversupply and waste of materials.

The formulas for estimating supplies for a single-surface treatment are as follows:

For computing pounds:

Step 1:

$(Pounds\ of\ Material\ Required)\ P = \dfrac{L \times W \times ROA_A}{9}$

Step 2:

Pounds Needed for *Waste*

$= Pounds\ of\ Material \times WF\ (.05\ or\ .10)$

Step 3:

Total Pounds Required

$= Pounds\ of\ Material + Pounds\ for\ Waste$

For computing tons:

Step 1:

$(Tons\ of\ Material\ Needed)\ T = \dfrac{L \times W \times ROA_B}{18,000}$

Step 2:

$Tons\ of\ Waste = Tons\ of\ Material \times WF\ (.05\ or\ .10)$

Step 3:

Total Tons of Material Required

$= Tons\ of\ Material\ Required + Tons\ Allowed\ for\ Waste$

The formula for gallons of bitumen required is as follows:

Step 1:

(Gallons of Bitumen Needed)

$G = \dfrac{L \times W \times (ROA_A \times ROA_B)}{9}$

Step 2:

Gallons for *Waste*

$= Gallons\ of\ Bitumen \times WF\ (.05\ or\ .10)$

Step 3:

Total Gallons Bitumen Required

$= Gallons\ of\ Bitumen$ for *Project*

$+ Gallons\ Allowed$ for *Waste*

Where:

P = weight of aggregate in pounds

T = weight of aggregate in tons

L = weight of treated surface in feet

W = width of treated surface in feet

ROA_A = rate of application of aggregate in pounds per sq/yd

ROA_B = rate of application of binder per pounds of aggregate per sq/yd.

WF = waste factor for bitumen 5% or .05 or 10% at .10

9 = square feet per square yard conversion factor

18,000 = 2,000 (pounds per ton) × 9 (square feet per square yard)

The materials for a multiple-surface treatment are determined by the same method as above except the application rate of the binder and the aggregate, and the size of the aggregate for the second lift is one half of that of the first lift.

Example: A test strip with an area of 100 square yards was used to determine the quantities for a single-surface treatment. Careful control was made of materials. A check of materials consumed showed that 1.50 tons of aggregate was used. Based on previous experience, an aggregate loss of 10 percent (0. 10) and a bitumen loss of 5 percent (0.05) are expected. Find the tons of aggregate and gallons of bitumen necessary to make a double-surface treatment on a road 24 feet wide and 10 miles long.

Solution:

(1) Aggregate 1st lift:

$$ROA_A = \frac{1.50 \; tons \; \times \; 2000 \; lb/ton}{100 \; sq \; yd} = 30 \; lb/sq \; yd$$

$$T = \frac{(10 \; miles \; \times 5,280 \, feet) \times 24(W) \times 30 \; (ROA_A)}{18,000}$$

$$+ \frac{380,160,000}{18,000} = 2,112 \; tons$$

$$Waste \; = 2112 \; tons \; \times \; .10 = 211.2 \; tons$$

$$211.2 \; tons \; waste \; + \; 2,112 \; tons \; = 2323.2 \; tons$$

A total of 2,324 tons of aggregate are required.

Aggregate 2nd lift:

NOTE: 15 = 1/2 of first lift

$$T = \frac{(10 \; miles \times 5,280 \, feet) \times 24(W) \times 15 \; (ROA_A)}{18,000}$$

$$= \frac{19,008,000}{18,000} = 1,056 \; tons$$

$$Waste \; = 1,056 \; tons \; \times \; .10 = 105.6 \; tons$$

$$105.6 \; tons \; waste \; + \; 1,056 \; tons \; = 1161.6 \; tons$$

A total of 1,162 tons of aggregate are required.

(2) Bitumen 1st lift:

$$ROA_B = 0.01 \; Gallon \; per \; lb \; of \; Aggregate \; per \; sq \; yd$$

$$B = \frac{(10 \; miles \times 5,280 \, ft.) \times (24W) \times (.01 \times 30 \; AR_A)}{9}$$

$$= \frac{380,160}{9} = 42,240 \; Gallons$$

$$Waste \; = 42,240 \; Gallons \times .05(WF) = 2,112 \; Gallons$$

$$Total \; Gallons = 2112 + 42,240 = 44,352 \; Gallons$$

Bitumen 2nd lift:

$$B = \frac{(10 \; miles \times 5,280 \, feet) \times 24(W) \times (15 \times 0.005)}{9}$$

$$= \frac{95,040}{9} = 10,560 \; Gallons$$

$$Waste \; = 10,560 \; Gallons \times \; .05(WF) \; = 528 \; Gallons$$

$$Total \; Gallons \; = 528 \; + \; 10,560 \; = 11,088 \; Gallons$$

Compute Bituminous Material

Several methods are used to calculate the amount of hot-mix material required for paving projects; however, when the weight of a hot-mix per square yard or cubic foot is not known, two equations are used in the NCF to compute the number of tons of asphalt required for a project. These equations are as follows:

Equation 1

$$Tons \; of \; Asphalt \; = \frac{L \times W \times D \times 146}{2000} = Tons \; \times \; (WF)$$

$$= Percent \; of \; Tons \; + \; Tons \; = \; Tons \; Required$$

Where:

L = length of project in feet

W = width of project in feet

D = depth or thickness of compacted mat. You must change inches into feet by dividing the number of inches by 12 (inches in 1 foot). For paver screed height, add 1/8 inch for each inch of the mat to be paved. (Example: for a 2-inch mat, two blocks of wood 2 1/4 inch thick will be required to set under the screed.) The blocks must be thicker than the finished compacted mat to allow for additional compaction by rollers

146 = This number represents the approximate weight of 1 cubic foot of compacted hot-mix asphalt. This number can vary from 140 to 160 pounds; however, 146 pounds equals the 110 pounds per square yard per 1-inch depth of asphalt used in the second equation for figuring tons require for asphalt. (See table 8-5.)

WF = Waste factor equals 5% or .05, or 10% or .10, depending on the experience of the screed operators and handwork required on the project

2,000 = 2,000 pounds is equal to one ton; therefore, you must divide the total weight of material by 2,000, giving tons required.

Table 8-6.-Weight and Volume Relations for Various Types of Compacted Asphalt Pavement.

Note: Because of the considerable variations of specific gravity, gradation, and other characteristics of mineral aggregates, weight per unit volume of compacted asphalt pavement varies considerably. Exact weights per unit volume should be determined in the laboratory from samples taken from the pavement or prepared in the laboratory with the same materials as used in the field.	Pounds Per Cubic Foot	Pounds Per Cubic Yard	Pounds Per Square Yard Per 1 inch Depth	
	100	2700	75	
	105	2835	79	
	110	2970	83	
	115	3105	86	
	120	3240	90	
	125	3375	94	
	130	3510	97	
	135	3645	101	
	140	3780	105	
	145	3915	109	
	150	4050	112	
	155	4185	116	
	160	4320	120	
	Range	Range	Range	Frequently Used for Preliminary Estimate
Macadam-A.1. Type I or Penetration Macadam	110-135	2970-3645	82-101	95
Open Graded-A.I. Type II	115-140	3105-3780	86-105	100
Coarse Graded-A.I. Type III	130-150	3510-4050	97-112	105
Dense Graded-A.I. Type IV	135-155	3645-4185	101-116	110
Fine Graded-A.I. Type V	130-150	3510-4050	97-112	105
Stone Sheet-A.I. Type VI	130-150	3510-4050	97-112	105
Sand Sheet-A.I. Type VII	120-140	3240-3780	90-105	100
Fine Sheet-A.I. Type VIII	120-140	3240-3780	90-105	100
Mixed-in-Place Macadam-A.I. Spec. RM-1	110-135	2970-3645	82-101	95
Mixed-in-Place Dense Graded-A.I. Spec. RM-2	110-135	2970-3645	82-101	95
Mixed-in-Place Sand Asphalt-A.I. Spec. RM-3	100-125	2700-3375	75-94	85

Equation 2

$$Tons\ of\ Asphalt = \frac{L \times W}{9}$$

$$= Square\ Yards \times \frac{110\ Pounds\ Per\ 1'' Mat}{2000}$$

$$= Tons \times WF = Percent\ of\ Tons + Tons = Tons\ Required$$

Where:

L = Length of project in feet

110 = Pounds per square yard of asphalt per 1 inch depth. (Example: A 2-inch mat will equal 220 pounds per square yard.)

9 = To obtain square yards from square feet, divide by 9

2,000 = 2,000 pounds equal one ton; therefore, you must divide the total weight of material by 2,000, giving tons required.

WF = Waste factor equals 570 or .05, or 10% or .10, depending on the experience of the screed operators, and handwork required on the project.

Example: The specifications for a parking lot paving project are as follows:

L = 90 feet

W = 30 feet

D = 2 inches

WF = .10

Find the amount of asphalt required for this project.

Solution:

$$Equation\ 1 = \frac{30\ feet \times 90\ feet \times .167 \times 146}{2000}$$

$$= \frac{65831.4}{2000} = 32.9$$

(32.9 is rounded off to 33)

$$WF = 33 \times .10 = 3.3$$

$$Total\ Tons\ Required = 3.3 + 33 = 36.3$$

(36.3 is rounded off to 37)

$$Equation\ 2 = \frac{30\ feet \times 90\ feet}{9} = 300\ square\ yards$$

$$\frac{300\ square\ yards \times 220}{2000} = 33$$

$$WF = 33 \times .10 = 3.3$$

$$Total\ Tons\ Required = 33 + 3.3 = 36.3$$

Estimates for Asphalt Plants

The amount of materials comprising the plant mix can be best determined by a proportionate method. This is demonstrated by the following example:

Example: The required tonnage of plant mix for a project is 800 tons. The aggregate blend is 50/40/10 (percentage coarse aggregate/fine aggregate/mineral filler). The bitumen content is 6 percent. How many tons of each aggregate are required?

The job mix formula is as follows:

$$\frac{100 - OAC}{100} \times Percent\ AGG$$

$$= Adjusted\ Percent\ of\ AGG$$

OAC = Optimum Bituminous (Asphalt) Content

Solution:

Total aggregate percent by weight= 100 – 6 = 94 percent, or 0.94.

Coarse/aggregate = 0.94 x 50 percent = 47.0 percent by weight of the total mix.

Fine aggregate = .094 x 40 percent = 37.6 percent by weight of the total mix.

Mineral filler = 0.94 x 10 percent = 9.4 by weight of the total mix.

To convert to tons, multiply the required tonnage of plant mix by the percentage of each component of the mix. The results should be adjusted so that the sum of the tonnage of components is equal to the required tonnage of plant mix.

Coarse aggregate = 800 x 0.470 = 376.0 tons

Fine aggregate = 800 x 0.376 = 300.8 tons

Mineral filler = 800 x 0.094 = 75.2 tons

Bitumen = 800 x 0,060 = 48.0 tons

800 tons

(The bitumen weight was calculated as a check.)

Tons per hour

The equation used to compute the amount of asphalt that can belayed with a paver per hour is as follows:

$$Tons\ per\ hour = \frac{L \times W \times D \times 146}{2000} \times 60$$

Where:

L = Feet per minute. The NCF uses 11 feet per minute for planning purposes,

W = Width of the paver screed

D = Depth or thickness of compacted mat

146 = This number represents the approximate weight of 1 cubic foot of compacted hot-mix asphalt

60 = 60 minutes in one hour

2000 = There are 2,000 pounds in 1 ton

Example: The required tonnage of hot-mix asphalt for a project is 800 tons. The screed of the paver is set at 10 feet, and the depth of asphalt is 2 inches. Estimate the amount of asphalt that can be laid per hour.

Solution:

$$\frac{11 \times 10 \times .167 \times 146 \times 60}{2000} = \frac{160921.2}{2,000}$$

$$\frac{160921.2}{2,000} = 80.46\ tons\ per\ hour$$

By planning and estimating the amount of hot-mix asphalt that can be laid per hour, you are able to tell the asphalt plant exactly how much hot-mix asphalt is required to be delivered per hour and/or per day.

ASPHALT PLANT SAFETY

You must always be safety conscious and on the alert for potential dangers to personnel and property. Safety considerations cannot be overemphasized.

Coal distillate, such as benzene or naphthalene in benzol, are suspected carcinogens. Avoid all skin contact and do not inhale the vapors and gases from these distillates. Asphalt contains components suspected of causing cancer. Anyone handling asphalt must be trained on the health hazards.

Dust is particularly hazardous because of its threat to your lungs and eyes. Additionally, dust contributes greatly to poor visibility when trucks, front-end loaders, or other equipment are being used around the stockpiles or cold bins. Reduced visibility in work traffic is a prime cause of accidents.

Noise can be a double hazard. Noise is not only harmful to your hearing but also distracts your attention from moving equipment or other dangers.

Moving belts transporting aggregates should be a constant concern, as should belts to motors and sprocket and chain drives. All pulleys and belts and drive mechanisms should be covered or otherwise protected. Loose clothing that can get caught in machinery should never be worn at an asphalt plant.

Good housekeeping is essential for plant safety. The plant and yard should be kept free of loose wire or lines, pipes, hoses, or other obstacles. High-voltage lines, field connections, and wet ground surfaces are other hazards. Anyloose connections, grayed insulation, or improperly grounded equipment should be reported immediately.

Plant workers should not work on stockpiles while the plant is in operation. Personnel should **NOT** walk or stand on the stockpiles or on the bunkers over the feeder gate openings. Many workers have been pulled down into the material and buried alive so quickly that nothing could have been done to save them.

Burner flame and high temperatures around plant dryers are obvious hazards. Control valves that can be operated from a safe distance should be installed on all fuel lines. Flame safety devices also should be installed on all fuel lines. Smoking should not be permitted near asphalt or fuel storage tanks. Check frequently for leaks in oil heating lines and steam lines or jacketing on the asphalt distribution lines. Be sure safety valves are installed in all steam lines, and they are in working order. Make use of screens, barrier guards, and shields for protection from steam, hot asphalt, hot surfaces, and similar dangers.

When you are handling heated asphalt, use chemical goggles and a face shield. All shirt collars should be worn closed and cuffs buttoned at the wrist. Gloves with gauntlets that extend up the arm should be worn loosely so that they can be flipped off easily if they become covered with hot asphalt. Pants should remain bloused.

Exercise extreme care when climbing around the screen deck. All stairs and platforms should have secure handrails.

Hard hats should be worn by all personnel.

Truck traffic patterns should be planned with both safety and convenience in mind. Trucks entering the plant to pick up a load of hot mix should not have to cross the path of loaded trucks leaving the plant. If at all possible, trucks should not have to back up.

All operators should know the three horn signals.

- One blast on the horn, STOP,
- Two blasts, GO FORWARD,
- Three blasts, BACKUP